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Space Power Facility Readiness for Space Station Power System Testing

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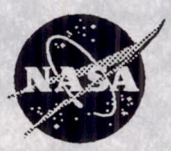

National Aeronautics and
Space Administration

SPACE POWER FACILITY READINESS FOR SPACE STATION POWER SYSTEM TESTING

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1. INTRODUCTION

1.1 Space Station Items

This document provides information which shows that LeRC's Space Power Facility (SPF) will be ready to execute the Space Station electric power system (EPS) thermal vacuum chamber testing. The SPF is located at LeRC West (formerly Plum Brook Station).

Various stages of Space Station testing have been planned for SPF. Presently, they are the PV Module Radiator Deployment Test and the Central Radiator Deployment Test.

Figure 1.1 is an artist's conception of SPF. Figure 1.1.1 shows the SPF chamber containing the PV radiator within its cryoshroud.

ACRONYMS

AC	air changes
AIS	Automated Information System
AHU	air handling unit
CAD	computer-aided design
CEI	contractor end item
CETS	cargo element transportation system
COTR	contractor officer's technical representative
CTW	cooling tower water
DEB	Development Engineering Building
DMW	demineralized water
EM	engineering model
EPS	electric power system
FEL	first element launch

FTR	fin tube radiator
FRS	facility requirements specifications
GFE	government furnished equipment
GSE	general support equipment
HVAC	heating, ventilating, and air conditioning
IACO	integrated assembly checkout
IEA	integrated equipment assembly
KSC	Kennedy Space Center
LDI	local data interface
LeRC	Lewis Research Center
LIMS	Lewis information management system
MAU	makeup air unit
MTAM	mass thermal acoustic model
MOO	Management Operations Office
NASA	National Aeronautics and Space Administration
NFPA	National Fire Protection Association
NHB	NASA Handbook
NMI	NASA Management Instruction
NRP	National Resource Protection
NSTS	National Space Transportation System
ORU	orbit replaceable unit
PBMO	Plum Brook Management Office
PC	personal computer
PDR	preliminary design review
PLC	programmable logic computer

PM	preventive maintenance
PMAD	power management and distribution
PSCN	program support communication network
PV	photovoltaic
R&D	research and development
RKDN	Rocketdyne
SCTS	space cargo transport system
SOW	statement of work
SPF	Space Power Facility
SS	Space Station
TBD	to be determined
TCS	thermal control system
TMIS	technical and management information system
TSD	Technical Services Directorate
UH	unit heater
UPS	uninterruptable power system
USAF	United States Air Force
VIT	video teleconferencing

1.2 Facility Items

The Lewis Research Center is responsible for the operation of the Space Power Facility (SPF) located in Sandusky, Ohio. The Space Power Facility (fig. 1.1) is the world's largest space environmental chamber. The facility was designed and constructed for the ground testing of space power systems in the environment the systems would experience in space with the exception of zero gravity. The types of systems that the facility was designed to accommodate include any type of electric power generating system up to 15 mwt as well as electric and chemical propulsion systems. The facility was originally designed to test nuclear power generation systems although nuclear systems have never been tested.

The SPF was constructed during the years 1964 to 1969. A wide variety of test programs was conducted from 1969 to 1975. In 1975, NASA placed the SPF in a standby mode in order to concentrate its resources

on the National Space Transportation System. The facility was maintained in standby mode by LeRC until 1979 when it was leased to the Garrett Corporation who used the facility for the manufacturing of gas centrifuges under a DOE contract. DOE canceled the gas centrifuge program in 1975 and has terminated Garrett's contract. The Garrett Corporation has removed all equipment associated with the DOE project. NASA and DOE executed an interagency agreement that provided for DOE reimbursement to NASA for the cost of repairing the damage done to the facility during the lease period. Repair work is complete and two pumpdown tests to check for vacuum integrity were conducted in December 1988.

This document describes the current Space Power Facility capabilities. It is the second revision and expansion of the Space Power Facility Plum Brook Station Facility Description Document, PIR No. 227, by William D. Pack, May 18, 1989.

1.3 Purpose

This document provides the details which show that SPF will be ready to support the SPF Thermal Vacuum Tests for Space Station.

1.4 Organization

Figure 1.4 shows the lines of authority and communication for the parts of the NASA-Lewis organization responsible for Space Station related testing at Lewis. The Power Systems Project Office is responsible for handling the budget for the Space Station in-line task at SPF (PV Radiator Deployment Test).

2 SPACE STATION FACILITY SUPPORT

As of August 1994, NASA was planning for qualification tests of the photovoltaic (PV) module radiator deployment mechanism and of the central radiator deployment mechanism in the Space Power Facility before committing the systems to duty on the Space Station.

In support of Space Station testing, modifications to the test facility are underway or completed. Installation of a large test-specific cryoshroud was completed in August 1994. Modification of the facility data acquisition system was also completed in August 1994. Rehabilitation of the cryogenic system was completed in June 1993.

3 GENERAL FACILITY DESCRIPTION

The LeRC SPF is located at the Plum Brook Station, Sandusky, Ohio . Plum Brook Station is a LeRC test facility complex located fifty miles west of Cleveland, Ohio as shown on figure 3. Figure 3.0.1 shows a plan view of the Space Power Facility with the three major areas:

(a) Assembly and Shop Area
(b) Test Chamber
(c) Disassembly Area

Three sets of standard gage railroad tracks, which connect externally to the SPF from the Plum Brook rail network, run through the three main areas. Therefore, one set of test hardware can be in the test or disassembly phase while a new set is being assembled. This plan also allows the flexibility of working on two different

tests set up from either end of the test chamber and alternating test time in the chamber.

3.1 Test Chamber

As shown in figure 3.1, the Space Power Facility test area consists of an aluminum test chamber surrounded by a vacuum-tight heavy concrete enclosure for nuclear shielding and containment.

3.1.1 Aluminum test chamber.—The test chamber is a vacuum-tight aluminum plate vessel consisting of a 100-ft diameter cylinder 72 ft high topped with a hemisphere. The highest point is 122 ft above the floor. The test chamber is capable of environmental testing in a vacuum from atmospheric to 10^{-6} torr and at cryogenic temperatures down to -250 °F by the addition of inner cryopanels. The aluminum vessel is designed for an external pressure of 2.5 psig and an internal pressure of 5.0 psig. The chamber is constructed of Type 5083 aluminum, which is clad on the interior surface with 1/8 in. thick Type 3003 aluminum for corrosion resistance. This material was selected principally because of its low neutron absorption cross-section, permitting personnel to enter the chamber within the minimum time following a nuclear test. The floor plate and vertical shell are 1 in. (total) thick, while the dome shell is 1-3/8 in. Aluminum structural T-section (2 ft depth and 1 ft width) members are welded circumferentially to the exterior surfaces. The chamber floor was designed for a load of 250 lb/ft^2.

The doors on the aluminum test chamber are curved to fit the cylindrical shape of the chamber. The two entrances are 50- by 50-ft in size and are 180° apart. One entrance is to the assembly area and the other is to the disassembly area. Double door seals are used to prevent leakage.

A 20 ton capacity vacuum compatible aluminum overhead polar crane is provided which may be removed during testing. The space beneath the chamber floor is isolated from the chamber free volume. The diffusion pumps are located beneath the chamber floor level and are sealed to the floor.

Other features of the test chamber include an air lock, (8×8 ft) a clear 50-ft wide floor working section, and a full complement of service penetrations. The chamber floor is heavily braced to withstand a load of 300 tons.

3.1.2. Concrete chamber enclosure.—The concrete test chamber enclosure structure serves as a biological shield and as a pressure chamber to contain internal pressure up to 8 psig. The structure is also designed to withstand atmospheric pressure externally while having a pressure of only 25 mm Hg absolute on the inside (between the test chamber and the concrete enclosure). The aluminum test chamber is enclosed within a 130-ft inside diameter, 6 to 7 ft thick cylindrical concrete shell with a hemispherical head, 132 ft high on the vertical centerline. The concrete contains a leak-tight 1/4 in. steel containment barrier imbedded within.

Two concrete doors with 50- by 50-ft openings are provided on the concrete enclosure. An airlock penetrates through the concrete enclosure into the aluminum test chamber. The airlock is an 8- by 8-ft opening. Other test chamber penetrations are provided for services such as electrical and control wiring, cooling water, and the vacuum system.

The penetrations are located below ground level for shielding purposes. All penetrations are welded. Expansion joints are provided as necessary. Wiring penetrations utilize leak-tight multipin connectors. Two series-connected isolation valves are provided in all penetrating piping systems.

3.2 Vacuum Pumping System

The basic vacuum system consists of thirty-two 48-in. diameter LN_2-baffled, electrically heated, oil diffusion pumps (capacity each - 43 000 l/sec.) mounted in the chamber floor plus two roughing trains of five stages each. Each roughing train consists of:

Stage 1	Two 500-hp Roots blowers—30 500 cfm total
Stage 2	One 500-hp Roots blower—18 300 cfm
Stage 3	One 300-hp Roots blower—9 900 cfm
Stage 4	One 200-hp Roots blower—4 720 cfm

Stage 5 Three Beach-Russ rotary-piston type mechanical vacuum pumps—2 160 cfm

The pumping system layout is shown in figure 3.2.

Typical pumpdown times for SPF are:

Atmospheric Pressure to 20 torr:	2 hr
20 torr to 10^{-3} torr:	6 hr
10^{-3} torr to 10^{-6} torr:	10 hr

3.3 Water Systems

3.3.1. Cooling Tower Water (CTW) System.—(Reference Drawings: PF41027, PF41028, PF41029, and PF41035)

A large wooden cooling tower located to the south side of the SPF is used to dissipate waste heat produced by such devices as the GN_2 compressors and the vacuum pumps. The system includes recirculating pumps, a water treatment plant, control valves, and a water supply.

The tower is of standard wood construction and includes a fire protection water deluge system. The CTW system has three vertical turbine recirculating pumps. Cooling tower water is chemically treated to reduce corrosion and contamination.

The CTW cools the vacuum roughing pumps, cryogenic equipment, "instrument" (service) air compressors, and their after–coolers.

3.3.2. Domestic and fire water.—A 150 000–gal water storage tower is installed at SPF and is connected to the domestic water system. The tower has a standpipe in the domestic water outflow line which limits the withdrawal of domestic water and leaves 90 000 gal of water in the tower. The bottom of the tank is connected to the fire water system so that, in an emergency, 90 000 gal of water is insured.

3.3.3. Demineralized Water (DMW) System.—(Reference Drawings: PF41006, PF 41020, and PF41023)

The DMW system was designed for two functions. The first, and primary, function is to provide cooling water to the diffusion pumps. The equipment associated with this system is depicted on PF41020 and includes a demineralizer, a storage tank, chillers, and piping. The other function was to provide DMW to the proposed cold/hot wall piping that was to cover the entire chamber walls (PF41023). That system was not implemented and piping connecting the DMW to the LN_2 and GN_2 piping for the cold wall has been terminated and the valves closed or removed.

The demineralizer in use employs ion exchanger resins to remove minerals from water run through the resin cartridges. The DMW is accumulated and stored in underground tanks. During operations, the water circulates through the demineralizer to provide make–up DMW. When the resins in the demineralizer become saturated, they are regenerated by sequentially flushing the resins with sodium hydroxide and sulfuric acid. This entire system of resins and reactivators are located in the southeast basement of the SPF.

Pumps P–20–1, –2, and –3, located near the demineralizer, operate in parallel to circulate the DMW to the diffusion pumps.

Two storage tanks are installed. The tank used for the diffusion pumps DMW, T–20–1, has a 1500–gal capacity. The unused tank for the cold/hot wall application, T–23–1, has a 26 000–gal capacity. The tanks are both of stainless steel construction and are buried on the south side of the SPF. In October 1994, there were plans to incorporate the 26 000–gal tank into the diffusion pump system.

Three Tonrac chillers are on–line to cool the diffusion pump DMW; two of the chillers provide 180 tons of refrigeration capacity and the third provides 90 tons. The total requirement of the diffusion pumps is only slightly more than 200 tons of refrigeration capacity; therefore, one 180–ton chiller and the 90–ton chiller are used. The third chiller is held in reserve.

3.4 Instrument and Service Air System

(Reference Drawing: PF41035)

The SPF has a large 650 CFM compressor (C–35–1) and a smaller stand–by compressor with a 170 CFM capacity (C–35–2). Both compressors discharge into the common header containing a receiver tank (V–35–1) with a condensate drain. The discharge of the receiver tank branches into two separate systems.

The first system, designated "plant or service air," receives no additional drying and is distributed throughout the facility. This is used for pneumatic tools and other devices requiring compressed air.

The second system, designated "instrument air," goes through two parallel "refrigifilters" and then through an absorption "LectroDryer" unit which is followed by a second receiver tank (V–35–2). The instrument air is then distributed around the facility to valve operators, solenoids, and other moisture sensitive devices.

3.5 Gaseous Nitrogen

Gaseous nitrogen is available from a rack of cylinders kept at SPF. These cylinders are replenished by vaporization from the supply in the liquid nitrogen tank. See Cryogenic System, Section 3.7.

3.6 Cryoshroud

The facility had a 40-ft diameter by 40-ft high cold wall. The four quadrants of this cold wall have been incorporated into the new cryoshroud as of 8/94. This cryoshroud is 40 ft wide by 80 ft long. The curved walls form a quonset hut shape, with a ceiling 22 ft high. It is separated into 10 zones with individual temperature control for each zone. See figures 3.6, 3.6.1, and 3.6.2. At the checkout in August 1994, an inlet temperature of -253 °F was achieved. Ninety-seven percent of the 65 thermocouples on the cryoshroud indicated temperatures colder than -230 °F. In September 1994, the cryoshroud panels were stacked onto the cryoshroud floor for removal preceding the next test in the SPF chamber.

The cryoshroud floor is designed to withstand a uniform load of 50 lb/ft^2 (normal for most offices). There are sockets protruding through this floor on which hardware such as that for Space Station can be mounted. The temperature of the cryoshroud is controllable from ambient down to -250 °F.

3.7 Cryogenic System

There are two liquid nitrogen storage vessels on site. One has a capacity of 217 000 gal and the other 28 000 gal Figure 3.6.1 shows the LN_2 distribution system. The liquid nitrogen fill pumps circulate liquid nitrogen to the desuperheater (LN_2 injector) and to the diffusion pump baffles. The two nitrogen compressors circulate gaseous nitrogen to the cryoshroud. The maximum mass flow capacity of one compressor is 3811 lb/min. The liquid nitrogen supplied to the desuperheater is injected by the unit into the gaseous nitrogen flow stream. All refrigeration for the cryoshroud is provided by the cooling effect of this injection.

3.8 Solar Simulation/Thermal Lamp

A solar simulation lamp as described in NASA TM–68042 has been removed from the test chamber and placed in storage to prevent damage during the restoration work. It is not planned to reinstall this lamp. Also in storage is a thermal lamp system. Up to 7 MW of 1-kW tungsten lamps currently configured in a 16-ft diameter, 57-ft high heater are available to provide a variety of thermal simulation configurations.

3.9 General Lighting

The light level in all assembly and shop areas is similar to that in an office, and is sufficient for all anticipated operations. Portable lighting can be used for special situations.

3.10 Electrical Power System

The electrical power system in the SPF consists of three elements: utility service, backup power, and uninterruptible power.

3.10.1 Electrical utility service.—The Plum Brook station electrical power system is supplied by Ohio Edison over two separate 138 kV transmission lines from two separate substations, one from Greenfield and the other from Beaver. Then each line of power is stepped down to 34.5 kV at substation A and sent to substation H, near the SPF. The separate 3.45 kV lines are further stepped down to 4160 V by two 7500 kVA power transformers, T1 and T2. The 4160 V lines then power the west electric area and east electric area. Three 1500 kVA, 4160-277/480 V transformers (T2, T3, and T8) and two 1000 kVA, 4160-277/480 V transformers (T6 and T7) supply 480V to eastern and western motor control centers, panels, and various loads. There is also one 500 kVA transformer (T9) that supplies 277/480V power for the lighting system. 120/208 V service is available throughout the facility through east and west motor control centers, power panels, and power outlets.

3.10.2. Backup power system.—Currently there is a 1250 kW diesel/generator system at the SPF which was designed to provide emergency backup power to critical facility loads during a utility power outage. This system has not been used in many years. Refurbishment would require cleaning the fuel tank, replacing diesel parts, and rebuilding the water pumps. Wiring of critical loads to the system also needs to be accomplished before the backup power system is fully functional.

Once the diesel generator backup power system is refurbished, the 1750 hp diesel engine can be started with compressed air. Switchgear and transfer switches are provided to start the unit and switch the necessary loads to emergency power. The diesel generator can also be operated in parallel with the main utility system.

3.10.3. Uninterruptible power.—There is an on-line uninterruptible power system (UPS) which consists of a 125 V battery bank and a 9 kW dc to ac inverter. The system supplies failure-free power to emergency lights, critical instrumentation, and critical control systems with a power capacity of 240 A-hr.

3.10.4. Electrical building ground.—The electrical grounding system consists of a buried copper cable that encircles the SPF. The ground grid runs approximately 2 ft from the base of the building and is interconnected to every other column in the facility.

3.10.5. Instrumentation ground.—This ground is at one location of the building ground.

3.11 Instrumentation System

The instrumentation system at the Space Power Facility starts with the hard lines that run from the test chamber to the instrument room in the basement of the data and test control rooms. The flooring of the data and test control rooms is computer type flooring and can be lifted out in 2-ft^2 sections to expose the instrument basement. This allows placement of test consoles, data processing, data recording, and data reduction consoles anywhere in the area. The cabling can be dropped to the basement and routed to where it is needed. The penetrations to the chamber are located on the basement level.

Figure 3.10 shows the arrangement of the data acquisition area. Presently installed (1994) is a Masscomp 6600 high speed data acquisition system. It can take 1 million samples/sec. The floor space available in the

data acquisition area is 1751 ft^2.

3.11.1 Test chamber hard lines.—

250 Thermocouple circuits: Multialloy to aluminum chamber

300 Bridge-type circuits: 100 8-conductor shielded to aluminum chamber: shielded to CTU's

300 Signal monitor circuits: 2/C shielded to aluminum chamber

96 High-frequency circuits: Coax cable to aluminum chamber

156 Control circuits: 2/C number 16 shielded

155 Low-power circuits: 24-number 16, 84-number 8, 16-number 4

36 High-power circuit: 36 4/C 350MCM feeders (used for shroud heater)

To fully utilize all circuits simulataneously a new feed-through plate must be fabricated.

3.12 Data Systems

The SPF has two data systems, one called the Facility Data System and one called the Research Data Acquisition System.

3.12.1 Facility data system.—This system is based on a Modicon Programmable Logic Controller. Not only is it used to control and monitor the Cryogenic System, but also it will be used to display and record the conditions occurring in other parts of the facility such as the repressurization system, vacuum system, etc. There is presently no interconnection of this system with the Research Data System, but this could be done whenever necessary.

3.12.2 Research Data Acquisition System

SPF HIGH SPEED DATA ACQUISITION COMPUTER
Masscomp 6600
Current Configuration

Condensed Specifications

Analog Input Channels: 256 Single–Ended (in groups of 64), or 128 Differential (in groups of 32)

Discrete Event Inputs: 96 Optical Isolators (Opto 22) (Contact Closures) [Converts Analog Inputs to Discrete inputs]

Full Scale Analog Input Ranges: 0 to 10V
±5 V
±10V

A/D Converter Resolution: 12 Bit (4096 Levels)

Continuous Aggregate Sample Rate: up to 1.0 M Samples/sec
Scan Rate Accuracy: ±0.0025 percent (25 PPM)

Maximum Data Scew: 250 usec

RAM Capacity: 16 MB

Hard Disc Capacity: 2×663 MB

Approx. Data Storage Capacity: 500 M Data Samples

Real–Time Display: 19 in. GA1550, (1152×910 Pixels)

Printer: HP Laserjet II (Trend Plots and Tabular Data)

Archival Storage Media: 1/4 in. 150 MB Tape Cartridge
5-1/4 in. MSDOS Floppy Disk

Current Software Package: Laboratory Workbench (Concurrent Computer Corp.)

Other Features:

(a) Open Architecture based Industry–wide standards for hardware and software
(b) Real–Time UNIX Operating System
(c) Real–Time Graphics Subsystems
(d) Ethernet Communications Port

3.13 Control Rooms

The Space Power Facility has two test control areas. One is the facility control room of 828 ft^2 and the other is a test control area of 2556 ft^2 The facility control room has all the operation panels for the facility. The controls for the vacuum and cryogenic systems are located in this area. The test control room is currently empty. Test consoles can be built up at facilities external to SPF and moved into the test area along with the test hardware.

3.14 Disassembly Area

The disassembly area provides a space 70 ft wide by 150 ft long with a clear height of 76 ft (over 700 000 ft^3) for possible remote disassembly, cut-up, and packaging for shipment of nuclear test articles. The structure is concrete with walls 6 ft thick to provide shielding from gamma radiation. The area is provided with a remotely-controlled 20-ton overhead bridge crane. This equipment is operated from exterior galleries provided with shielding viewing windows. The internal surface of the disassembly area is epoxy coated. Since the area has extensive ventilation and contamination control, it makes an ideal clean area. The large capacity blowers can maintain positive or negative pressure in the area. The high efficiency filters can be replaced with absolute filters. The external door is 14 ft wide × 18 ft high. Modifications to this HVAC system will be made by LeRC as necessary to meet the Space Station contractors' requirements.

3.15 Assembly Area

The assembly area located adjacent to the test chamber is 75 ft wide by 150 ft long with a steel frame superstructure and a clear height of 80 ft. The adjacent shop area, which is in addition to the assembly area, is 50 by 150 ft with a similar superstructure and a clear height of 40 ft with a 10-ton capacity overhead crane. The assembly area is equipped with a 25-ton capacity overhead bridge crane and three sets of parallel railroad tracks which extend into the test chamber. All rails in the assembly area extend through the end of the building to the east railroad spur. Thus, rolling stock on the east spur could progress into the assembly area, the test chamber, the disassembly area, and then to the west spur. The exterior door of the assembly area is 50 ft $\times$ 50 ft. The shop area exterior door is 20 ft wide $\times$ 22 ft high.

3.16 Office Area

Integral to the SPF is a two story office building that has 45 offices. The standard office has 279 ft^2. There is a 1046 ft^2 combination viewing gallery/conference room adjacent to the test control area. Conference rooms of approximately 415 ft^2 (one on the first floor and one on the second) have been converted into laboratories by Garrett. They will be left as is until the best use for these areas are established.

3.17 Parking

The parking lot for the building is located across the street on the northeast side of the building. Visitor parking is permitted on the north side of the road in front of the SPF entrance.

3.18 Building Access

The main access to the building is through the office entrance facing the road. A driveway surrounds the building for access by service vehicles.

3.19 Miscellaneous Features

Utilities:

- Water System

  Potable water system from Sandusky with 150 000 gal of water storage in an elevated tank.

- Natural Gas

  A 4 in. 20 psig service line provides natural gas with a supply of up to 850 SCFM.

- Sanitary System

  A 15 000 gal/day sewage treatment system is provided.

- Cooling Tower
  An 8000 GPM cooling tower is provided for cooling with a capability for 120 GPM makeup.

- Demineralized Water System

  There is a demineralized water system consisting of a 1500 gal storage tank with 3 pumps, each having a capacity of 120 GPM at a head of 140 ft. The demineralized water can be cooled by a refrigeration system which has a capacity of 3650 tons.

- Compressed Air System

  Compressed air is available in all the major areas of SPF. It is supplied from a 650-CFM, 110-psig compressor. A backup-standby compressor capable of 70 CFM is tied in parallel to the system. The Plum Brook Station has a 1,000 CFM engine-driven portable compressor which could be used as needed.

3.19.1 Shop area.—This area, shown in figure 3.0.1, is adjacent to the Assembly Area. It is 40 ft wide × 150 ft long × 34 ft high and has a 10-ton crane. It has been restored, and is equipped with light machine shop power equipment and tools. The exterior door is 20 ft wide × 22 ft high.

3.19.2 Government provided facilities & equipment.—

Office Furniture - Typical Office Setup:

4 each - Desks
4 each - Chairs
1 each - Phone (per office)
1 each - Bookcase

Typical Small Shop Equipment

Drills
Lathes
Saws
Grinders
Tube Bender
Metal Brakes
Sandblasters
Welding Equipment
  Light-blocking weld booth with ventilation
  TIG welder
  Electric arc welder
  Oxy-acetylene welder
Material-Handling Equipment
  3000 lb electric lift
  Manually-operated pallet lifter
  Hand truck
Work Platforms
  500 lb capacity Grove 80 ft articulated boom man-lift
  Rolling aluminum scaffolding

3.20 Capability summary

System	Capability	Comments
Vacuum	5×10^{-6} torr	Demonstrated 7/26/90
Vacuum Pump System	32, 48-in. diffusion pumps; LN_2 baffled 2 Roughing trains 5 stages each	Operational
Test Instrumentation	Masscomp 6600 1.0 M Samples/sec Hard Lines check out	930 pairs of hard lines from chamber to instrument basement
Facility Power	34.5 V redundant source	Operational
Test Chamber Power	7 MW	Available
Facility Cryogenic System	LN_2 Storage: 217 000 gal 28 000 gal GN_2 at –250 °F	22 temperature - controlled GN_2 supply and return zones available. 12 zones operational 8/94.
Cryoshroud	40 ft wide × 80 ft long × 22 ft high (see 3.6)	Checked out and operational 8/94. Removed for storage 9/94.
Quartz Lamp Heaters	7-MW quartz lamp heater	1-kW lamps installed in two 180° cylindrical segments, each having a radius of 8 ft and a height of 57 ft. They are presently in storage.
Solar Simulation	400 kW - 1° 19 minutes collimination Arc lamp with mirrors	Lamp and mirrors in storage
Utilities	Domestic & fire protection	Operational
Potable Water	150 000 gal storage	
Cooling Tower	8000 GPM 120 GPM make-up	Operational
Natural Gas	4 in.-20 psig feed 850 SCFM	Operational

Service Air	650 CFM compressor with 70 CFM back-up	Operational
Test Chamber	100 ft dia. × 122 ft high aluminum chamber inside 120 ft dia. × 132 ft high concrete chamber. 20-ton polar crane 50 ft × 50 ft doors	Operational
Disassembly Area	70 ft wide × 150 ft long × 76 ft high Concrete structure epoxy coated 20 ton crane	Restored
Assembly Area	75 ft wide × 150 ft long × 80 ft high Standard superstructure 25 ton crane	Restored
Shop Area	40 ft wide × 150 ft long × 34 ft high 10 ton crane	Restored Equipped with light machine shop power equipment and tools

4 COMMUNICATION SYSTEMS

There are three communication systems in the SPF: the telephone, intercom, and paging.

4.1 Lewis Information Management System (LIMS)

The LIMS is a PC network throughout LeRC and the Plum Brook Station which provides the interconnection between individual PC workstations and virtually any computer service at the Lewis Research Center.

5 NASA LERC-PLUMBROOK/SECURITY

5.1 Physical Security

5.1.1 Security areas.—Within the NASA Physical Security Program, there are three types of secure areas: RESTRICTED, LIMITED, CLOSED. These physically defined areas can be established to provide the appropriate level of protection for NASA resources and contractor proprietary information. NASA LeRC management will be responsible for managing Space Station Program secure areas.

5.1.1.1 Restricted area: These areas are used to provide administrative and operational controls to protect

operations and functions which are vital or essential to the accomplishment of the NASA mission. The Lewis Research Center and Plum Brook Station are designated as RESTRICTED areas. Access is restricted to those NASA employees and Contractors having a NASA badge and a valid need.

5.1.1.2 *Limited area*: Within these restricted areas are LIMITED areas wherein security measures are applied for the safeguarding of sensitive or classified information and material, or unclassified property warranting special protection and in which uncontrolled movement of visitors or other unauthorized persons would permit access to such information and material or property, but within which such access may be prevented by appropriate visitor escort or other internal restrictions and control. Access into and within these areas is restricted to AUTHORIZED personnel only.

5.1.1.3 *Closed area*: These areas are used primarily for sensitive and/or classified information plus those mission or life critical operational areas. Access within these areas is restricted to those cleared personnel with a need to know. An audit trail of access to the areas will be maintained.

5.1.2 Building protection.—The Space Power Facility (SPF), located on the Plum Brook Station, is designated as a NASA National Resource under the NRP Program. These resources require a level of protection commensurate with their importance to the NASA mission.

5.1.3 Automated information system and computer area.—Access into areas containing sensitive or classified computer systems should be in accordance with the standards outlined in NASA Handbook 2410.9. For those NASA computer resources used in support of the Space Station Program, the NASA AIS Security Program, NMI 2410.7; NHB 2410.9; and the LeRC Computer Security Guide standards will apply.

5.2 Personnel Security

5.2.1 Contractor employee identification.—All contractor personnel requiring access to LeRC, in the performance of their contract, will be issued a contractor employee identification badge. To obtain entrance to the Plum Brook Station, this identification badge must be displayed to the security gate guard before proceeding.

5.2.2 Foreign Nationals.—Access to NASA resources by Foreign Nationals in visa/passport status will be accomplished using the procedures as defined in NMI1371.3 and 1371.4. Individuals in Permanent Resident Alien Status must present their "Green Card" for badging.

5.3 Information Security

5.3.1 Security awareness and training.—Although information protection will be applicable across all disciplines, a formal training and awareness process should be established. General NASA institutional security awareness will be provided by the NASA LeRC security branch and detailed operational security will be established by Space Station management.

6 FIRE AND PERSONNEL HAZARD PROTECTION

6.1 Building and Personnel Protection

For any emergency, dial 911 on the telephone to get the Plum Brook Station Communication Center. The answering person will take appropriate action. Fire extinguishers, blankets and hoses; first aid kits; stretchers and other emergency equipment are located as shown on figures 6.1 to 6.1.9.

6.2 Hazardous and Explosive Materials

Hazardous materials such as alcohol, cleaners, acetone, trichloroethylene, and other miscellaneous chemicals are stored in the Southeast side of the assembly area. Storage of hazardous materials is permitted only in this storage location.

6.3 Emergency Exit Routes

In case of an emergency, the escape routes are identified by Exit signs.

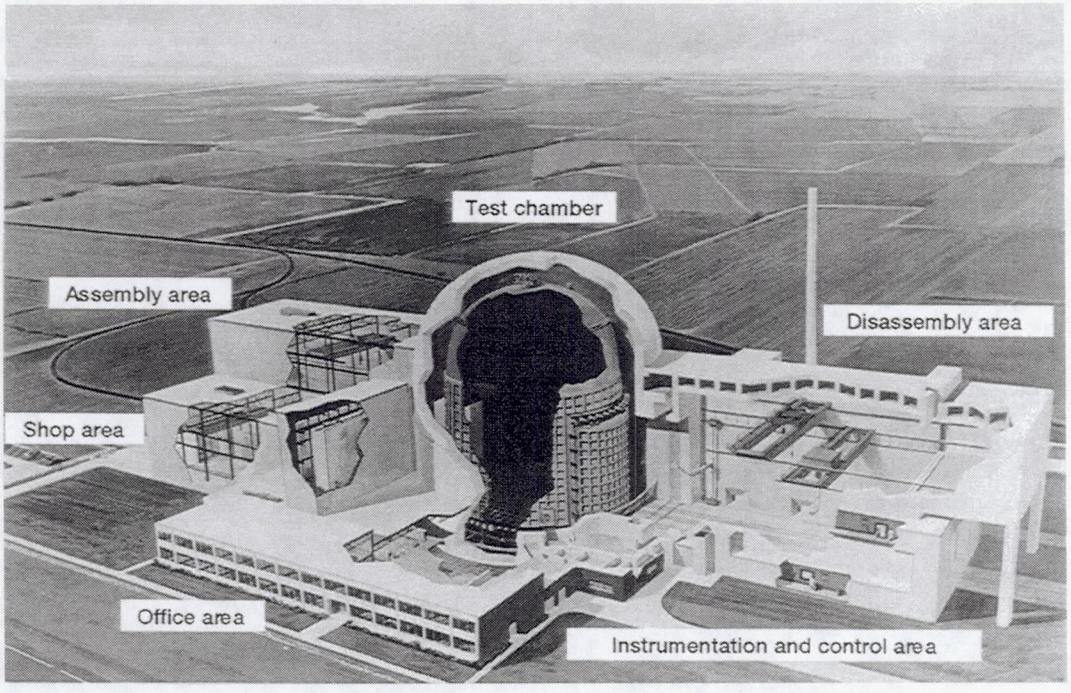

Figure 1.1.—Cutaway view of Plum Brook Space Power Facility.

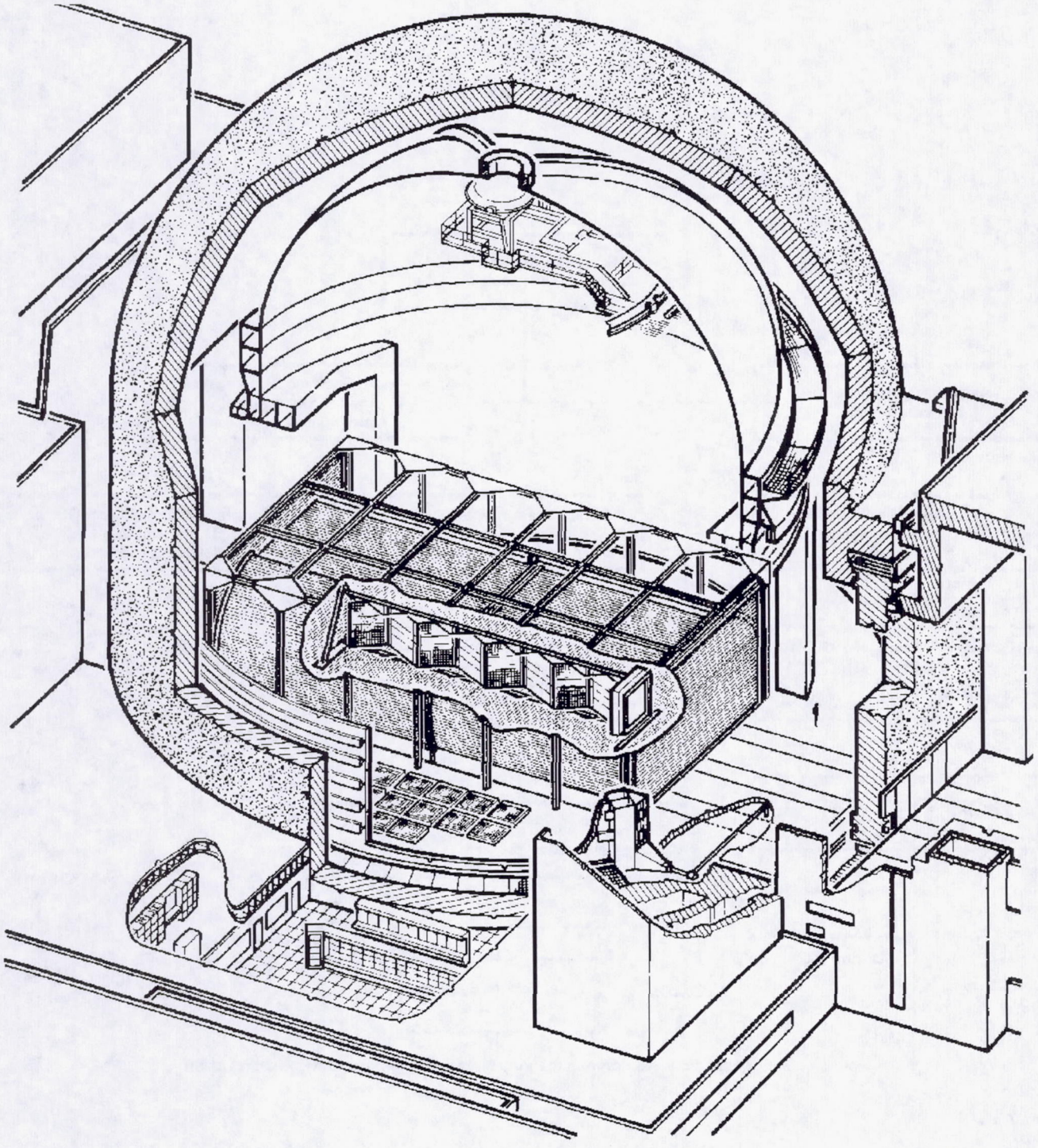

Figure 1.1.1.—SPF-PV radiator deployment test.

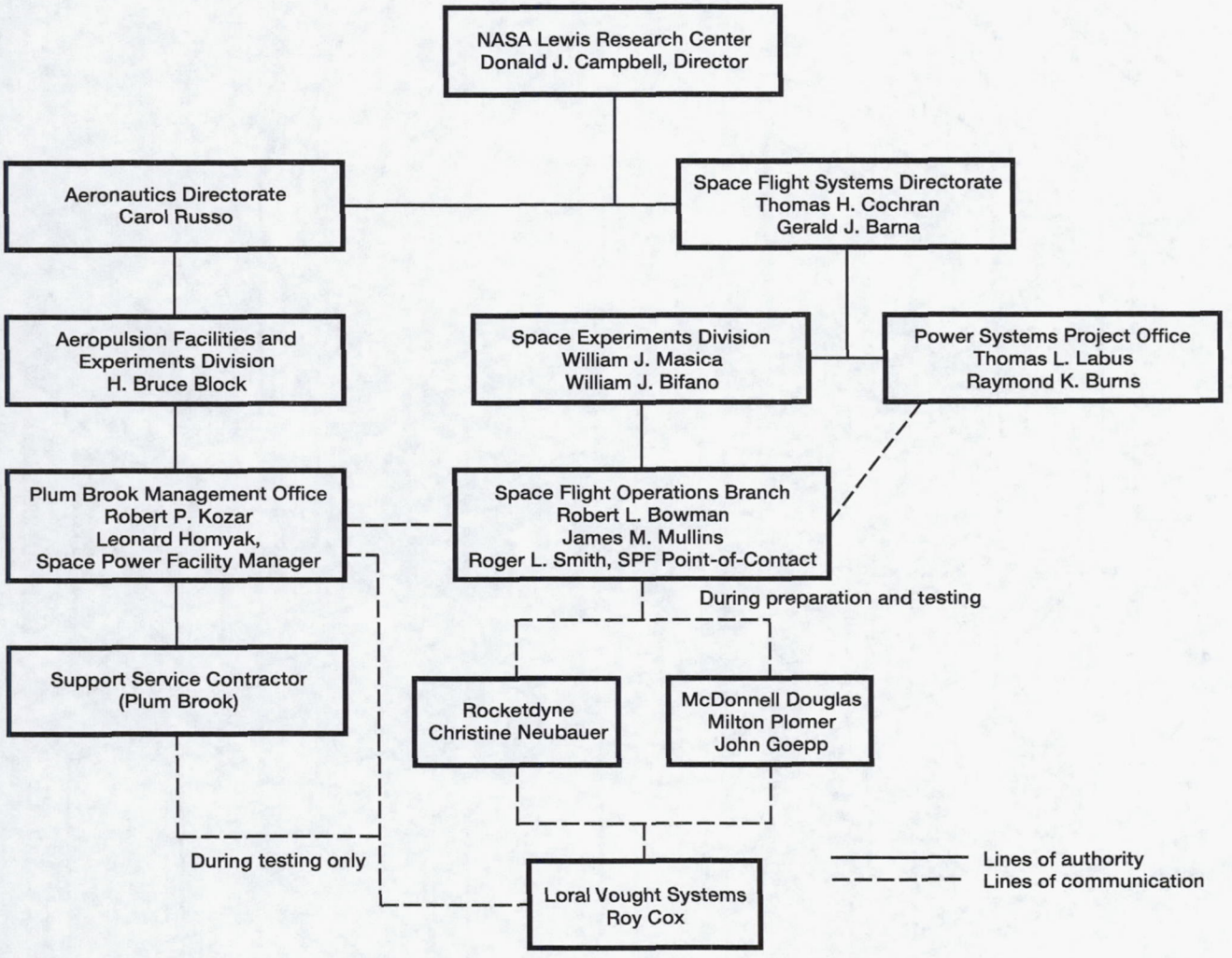

Figure 1-4.—Organization and communications channels for space station testing at SPF.

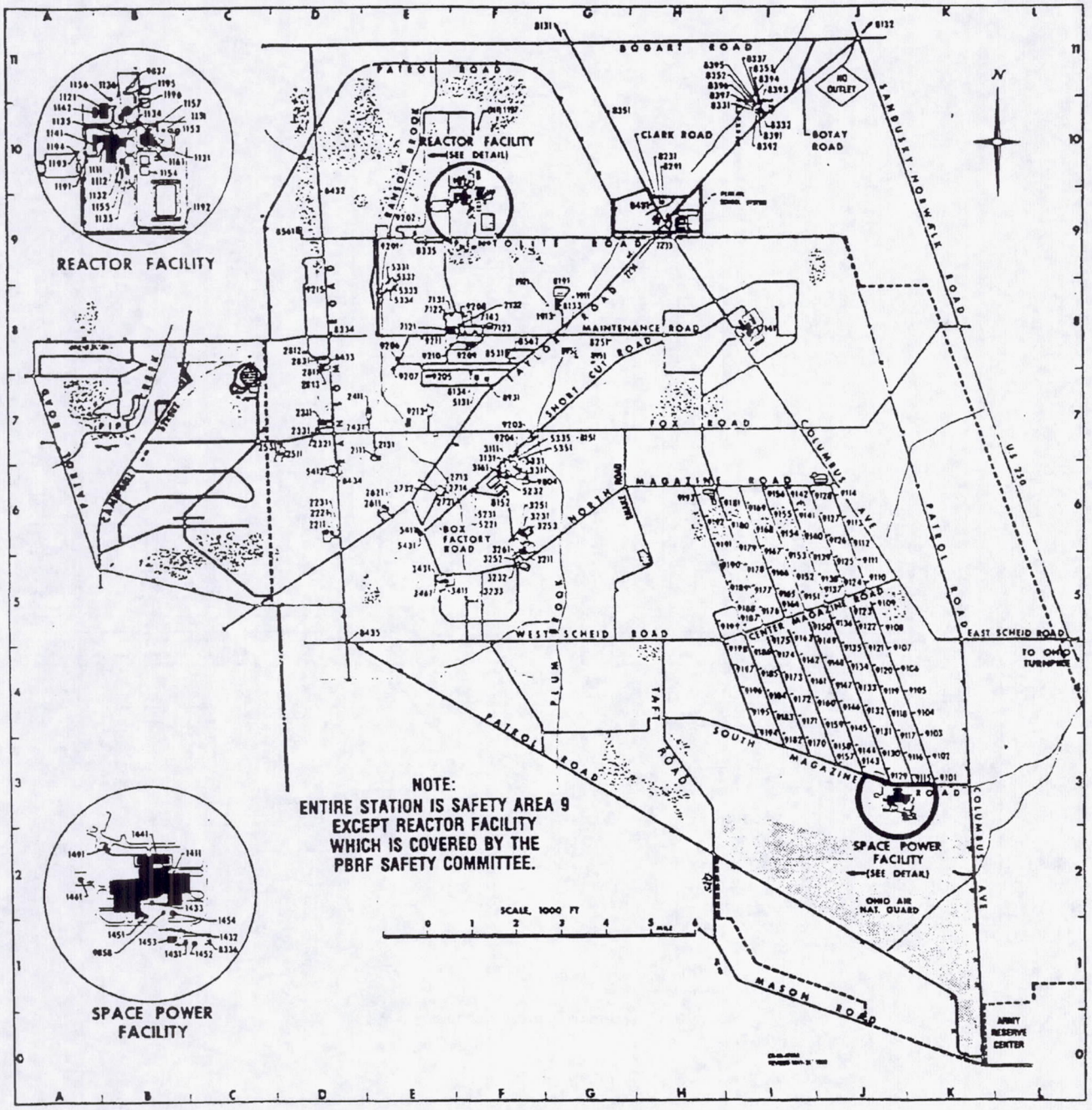

Figure 3.—Lewis Research Center; Plum Brook Station.

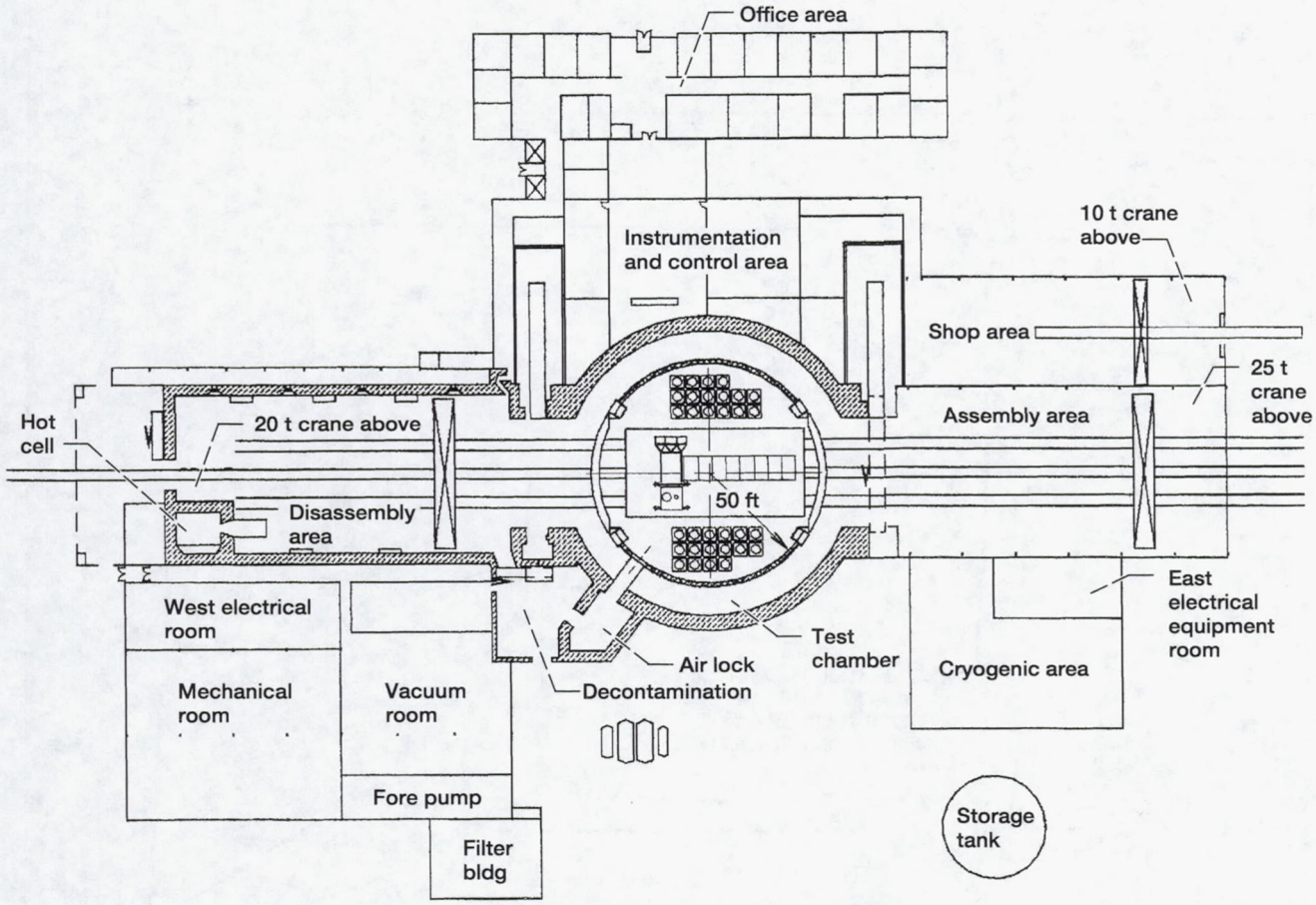

Figure 3.0.1.—Space Power Facility plan view.

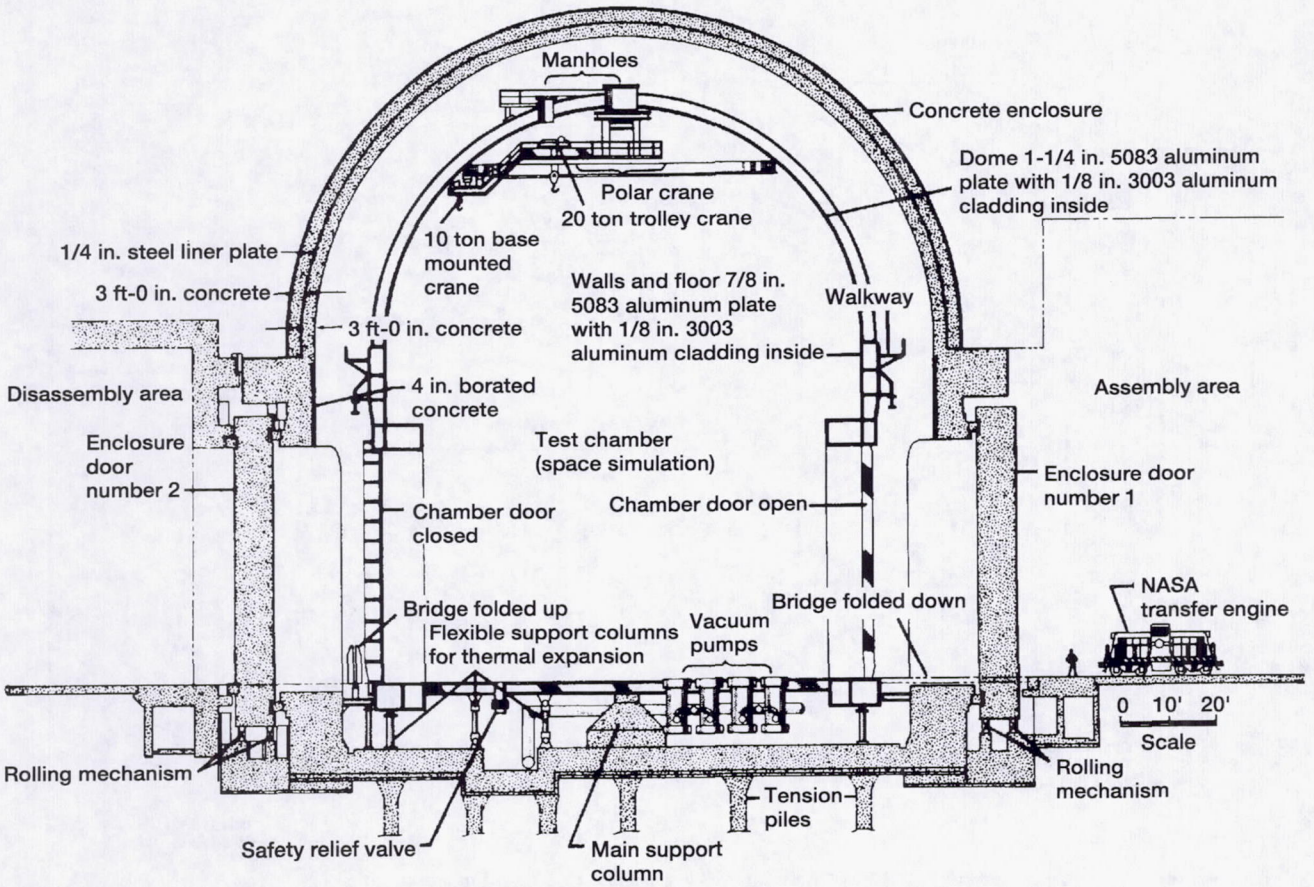

Figure 3.1.—Cutaway view of test chamber.

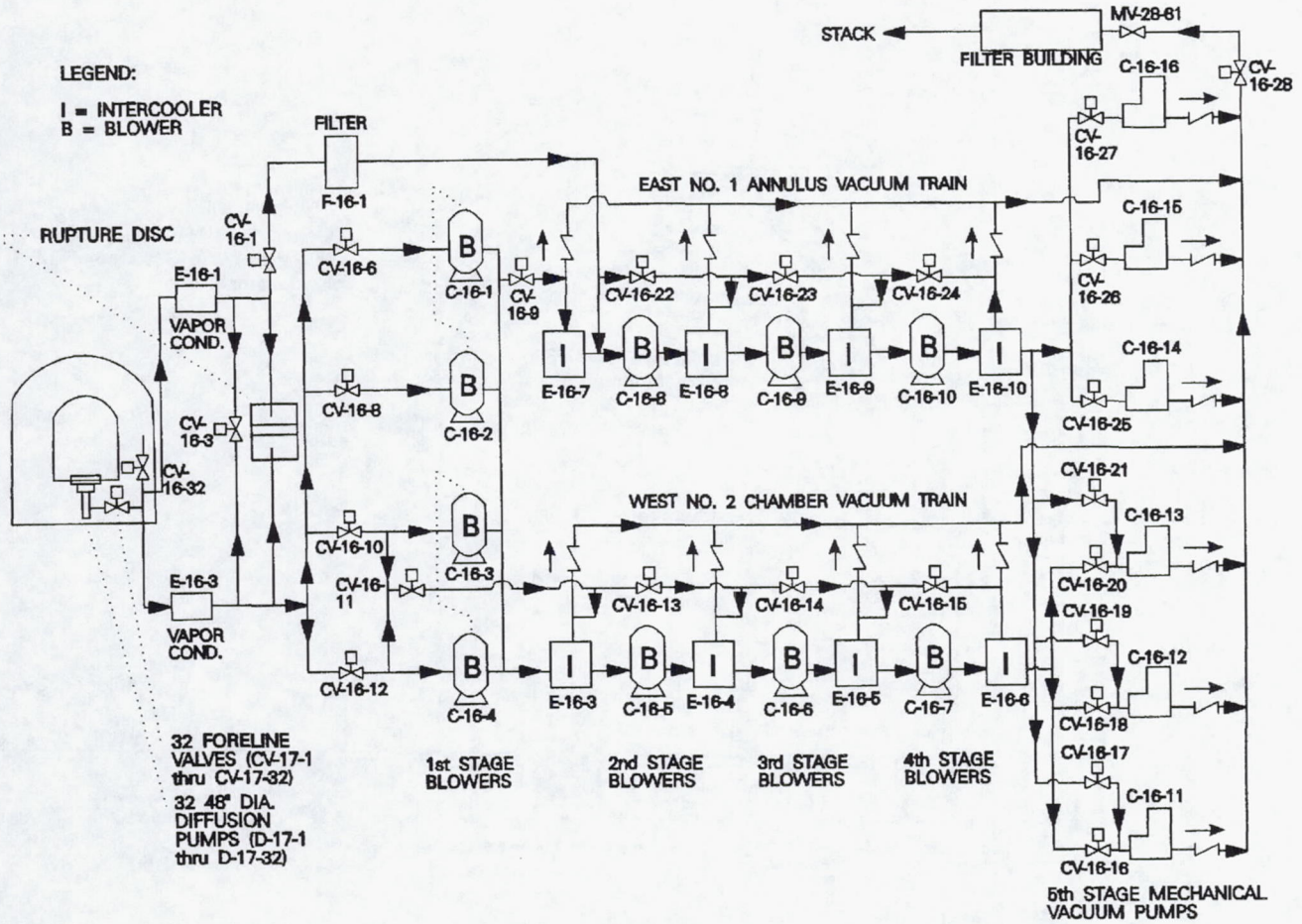

Figure 3-2.—Chamber and enclosure vacuum trains schematic.

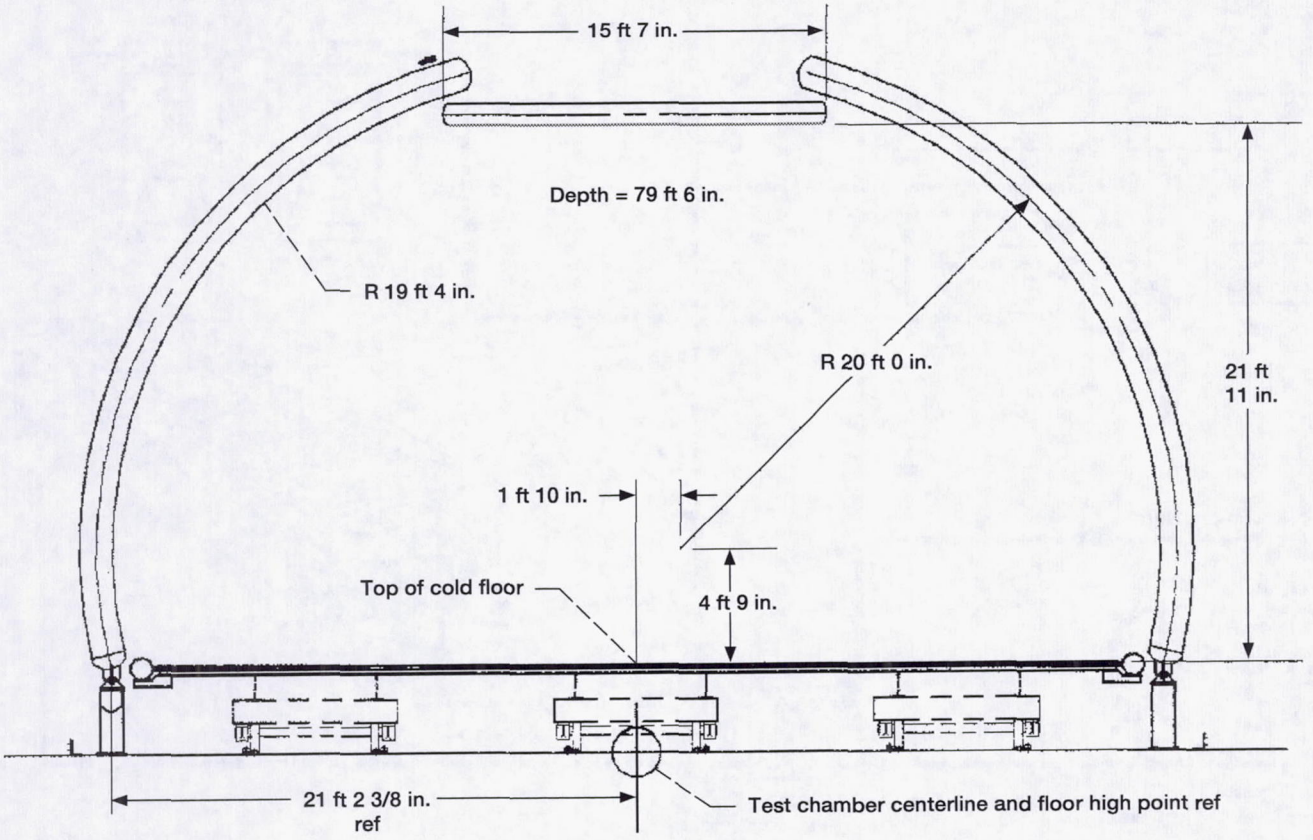

Figure 3.6.—Cryoshroud envelope.

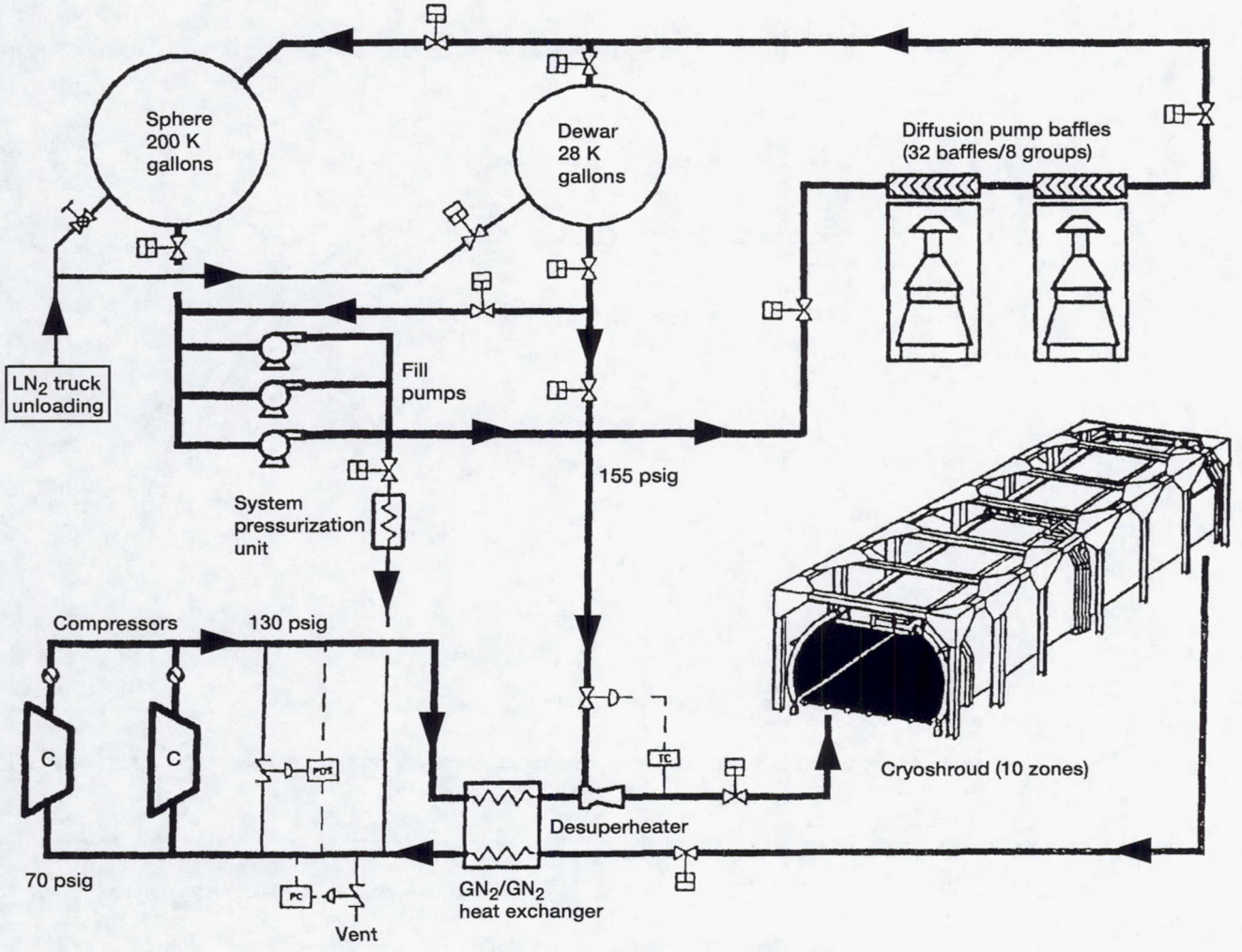

Figure 3.6.1.—SPF LN_2 and GN_2 distribution systems.

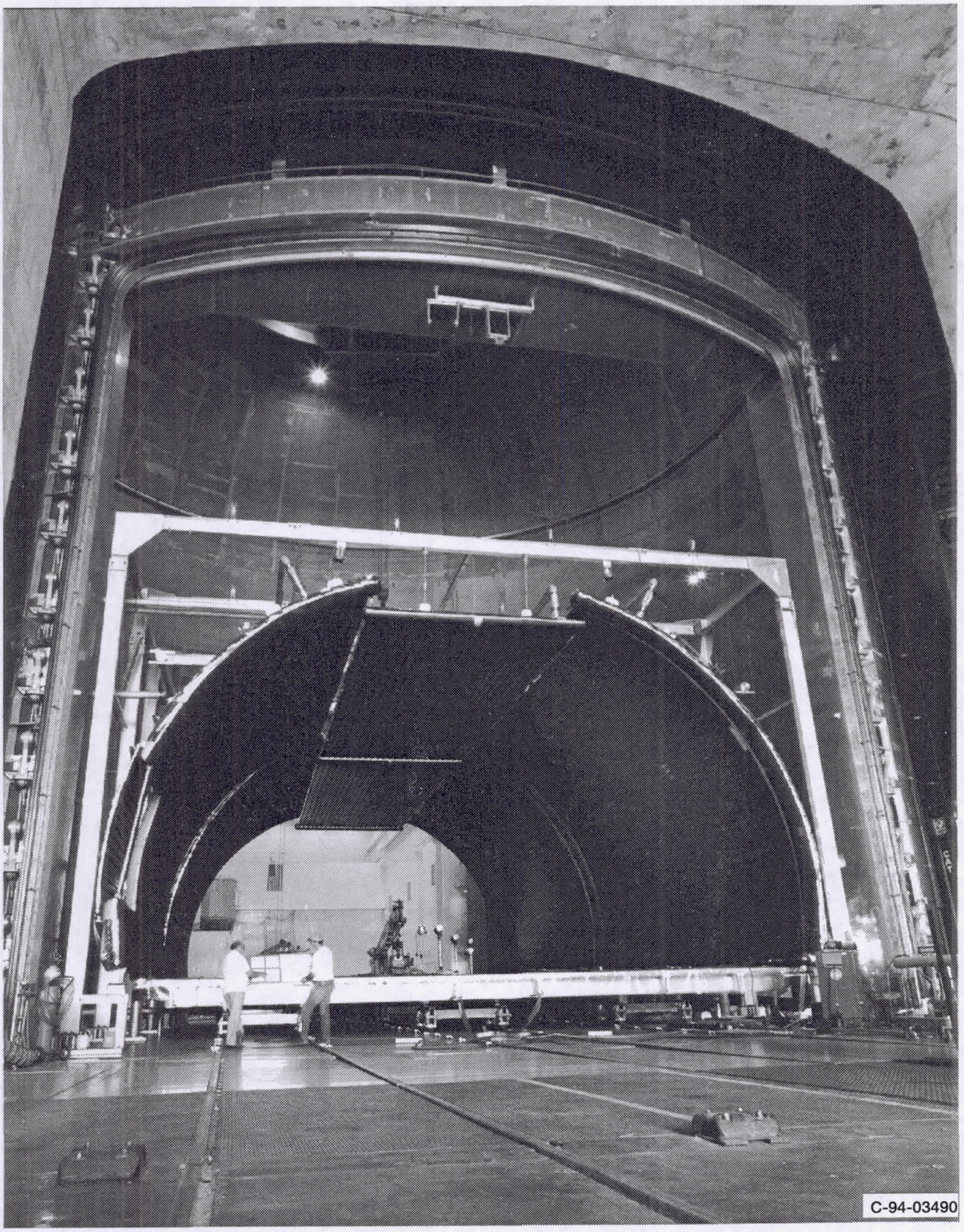

Figure 3.6.2.—SPF cryoshroud without end doors.

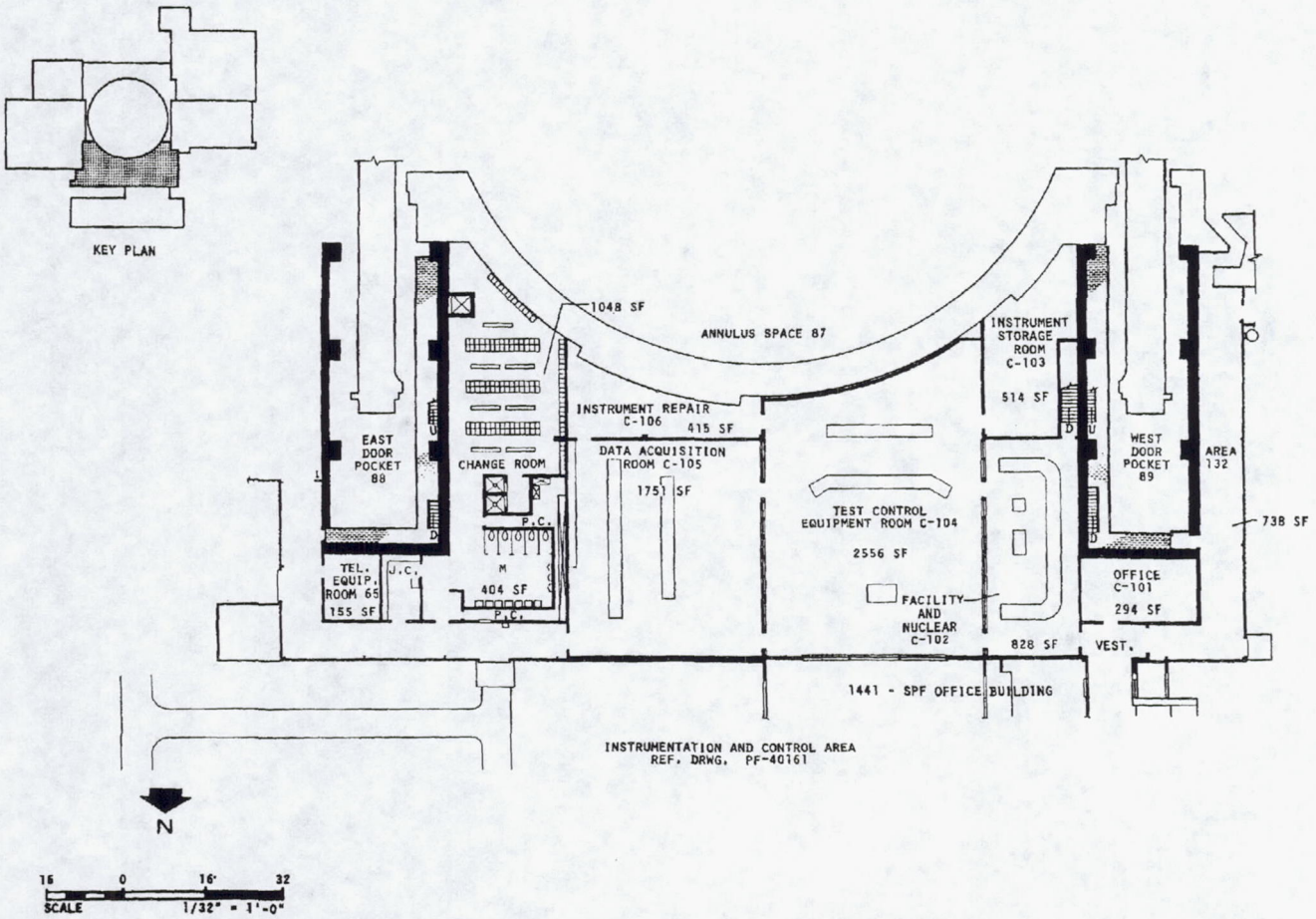

Figure 3.10.—NASA Lewis Research Center-Plum Brook Station; Sandusky, Ohio. SPF test building; building no. 1411.

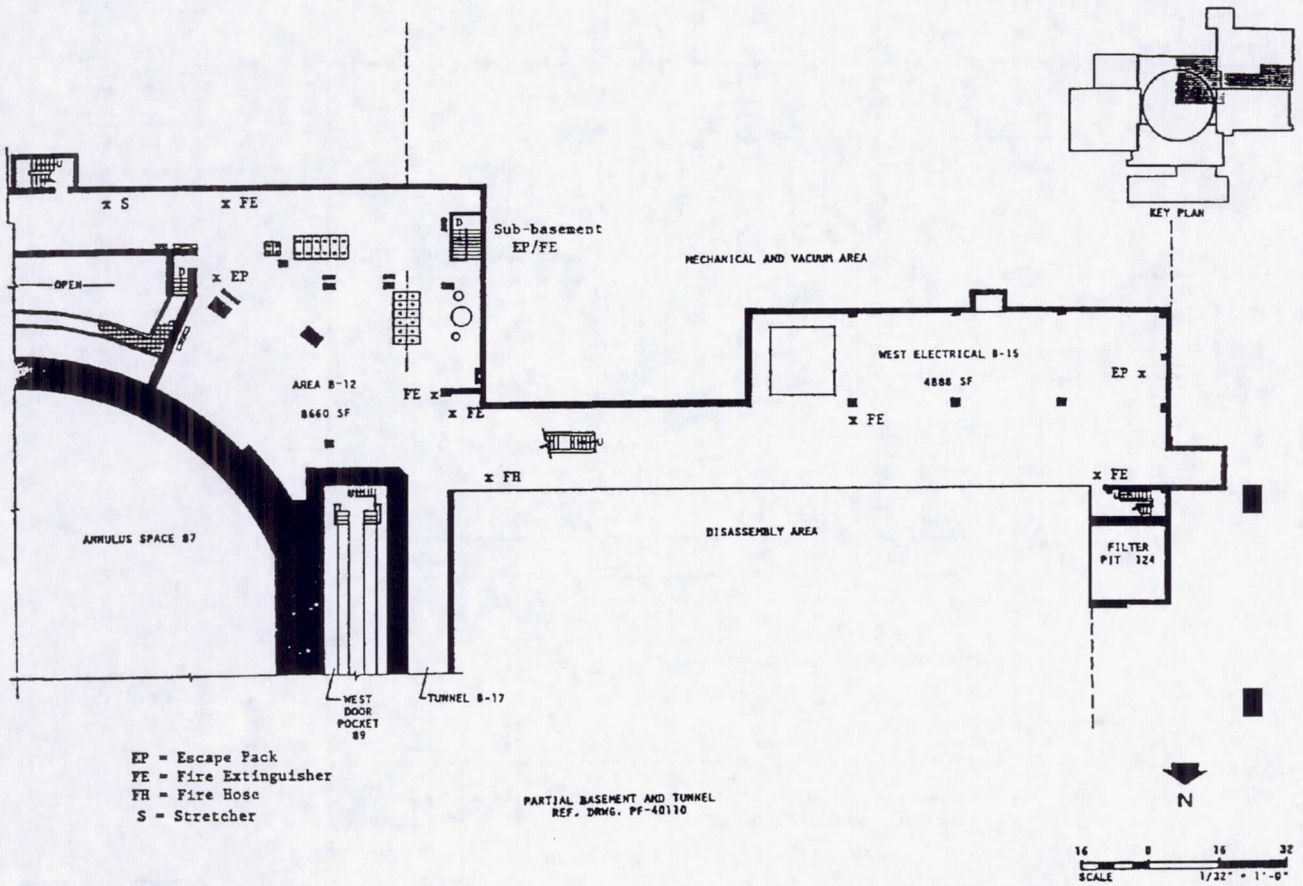

Figure 6-1.—NASA Lewis Research Center-Plum Brook Station; Sandusky, Ohio. SPF test building; building no. 1411.

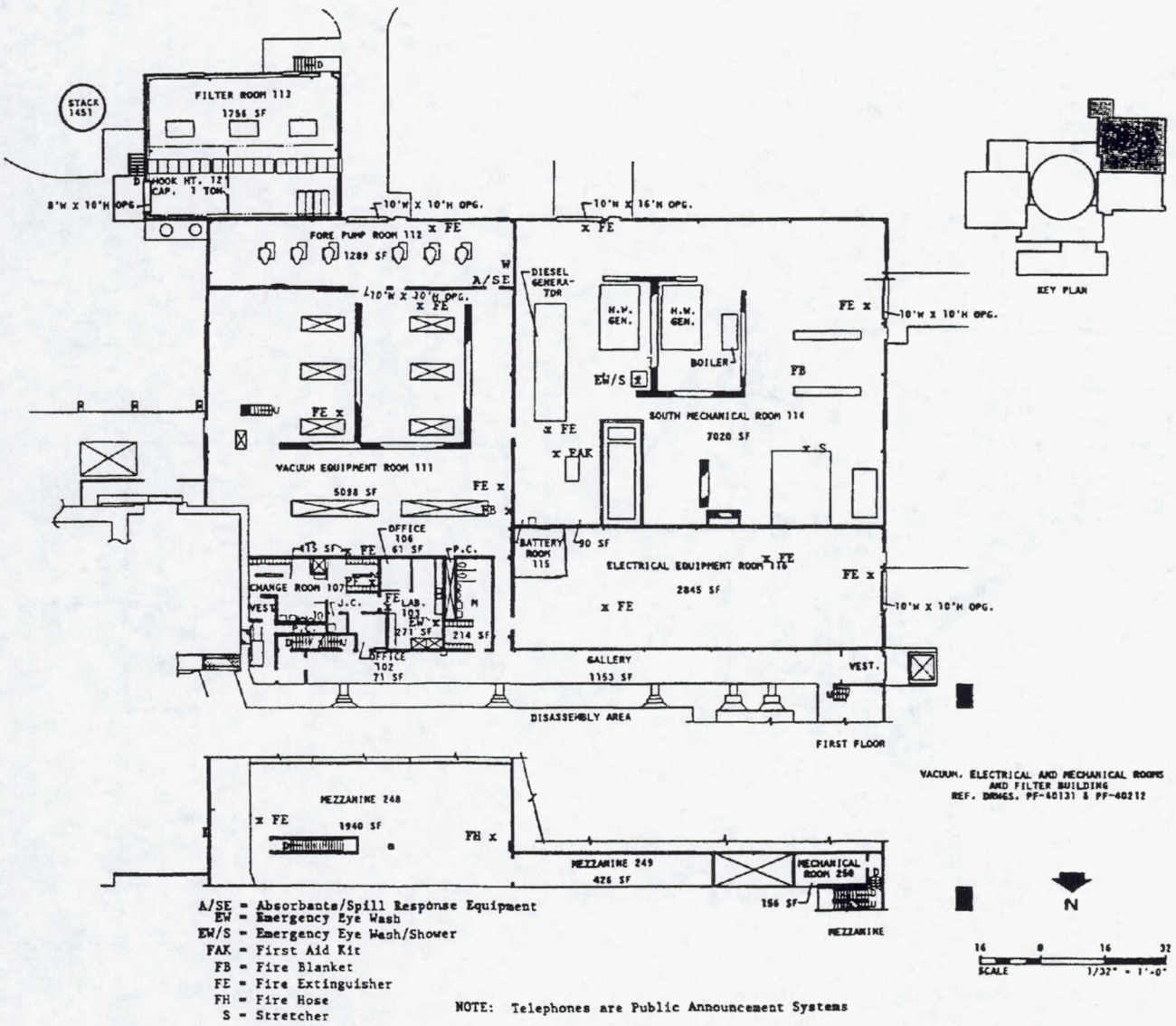

Figure 6.1.1.—NASA Lewis Research Center-Plum Brook Station; Sandusky, Ohio. SPF test building; building no. 1411.

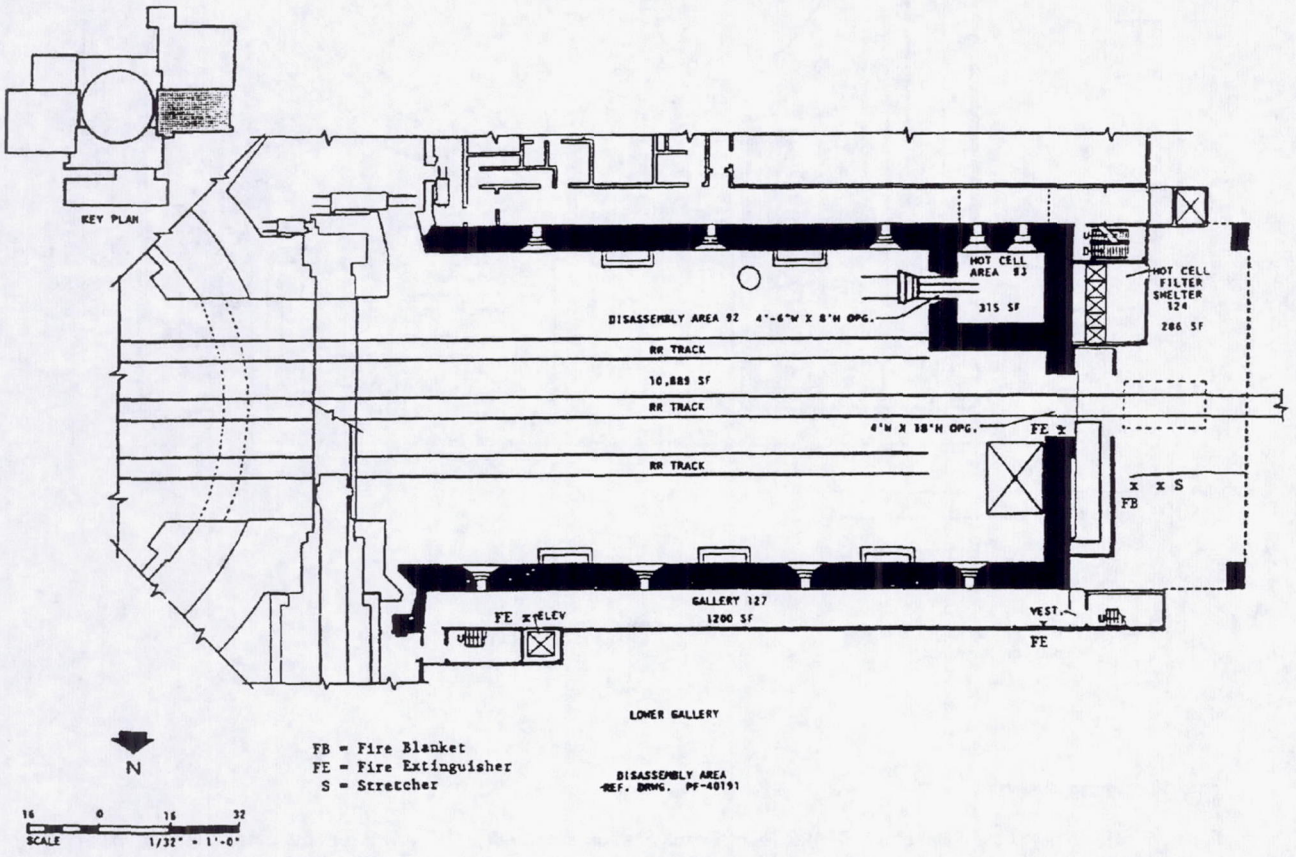

Figure 6.1.2.—NASA Lewis Research Center-Plum Brook Station; Sandusky, Ohio. SPF test building; building no. 1411.

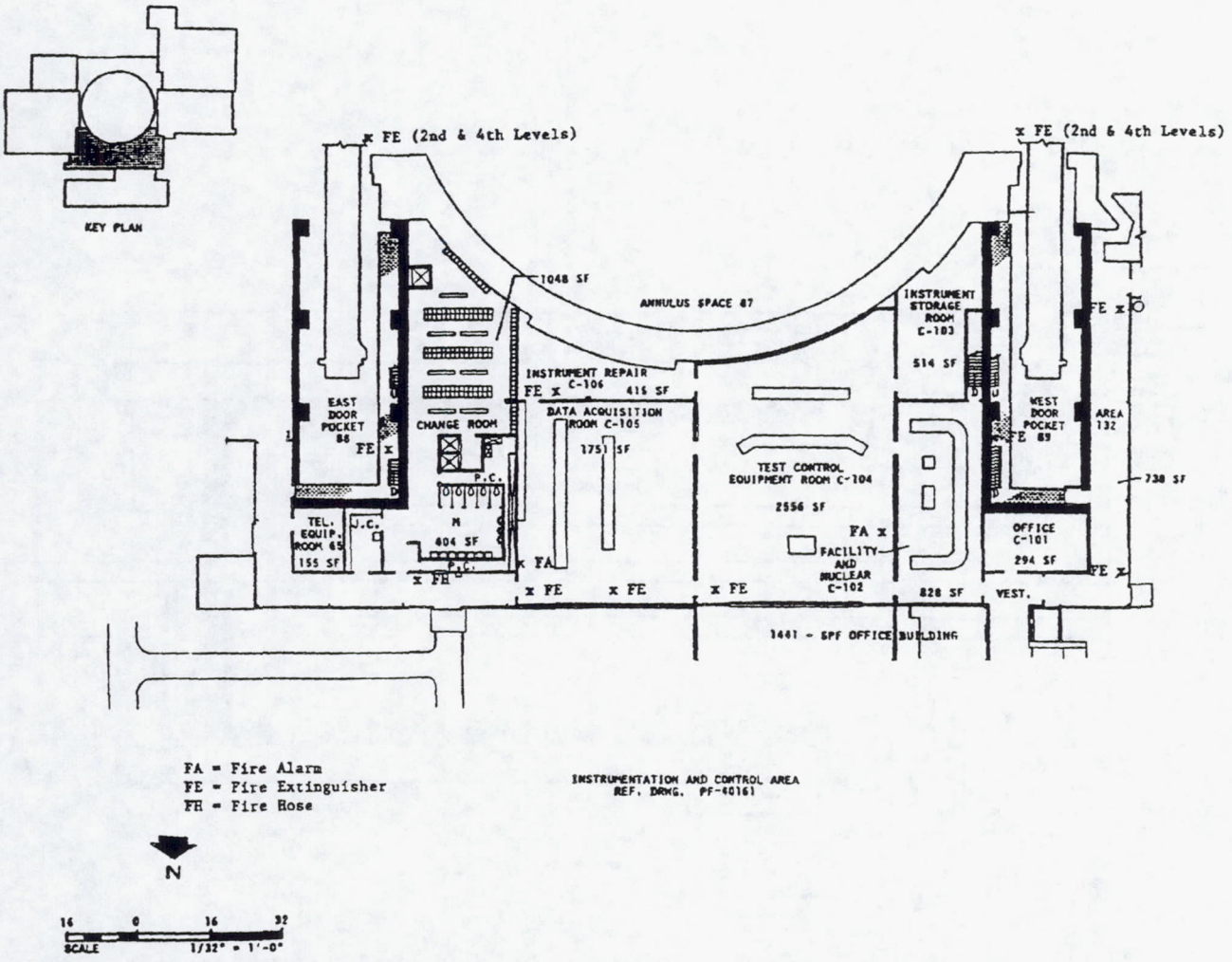

Figure 6.1.3.—NASA Lewis Research Center-Plum Brook Station; Sandusky, Ohio. SPF test building; building no. 1411.

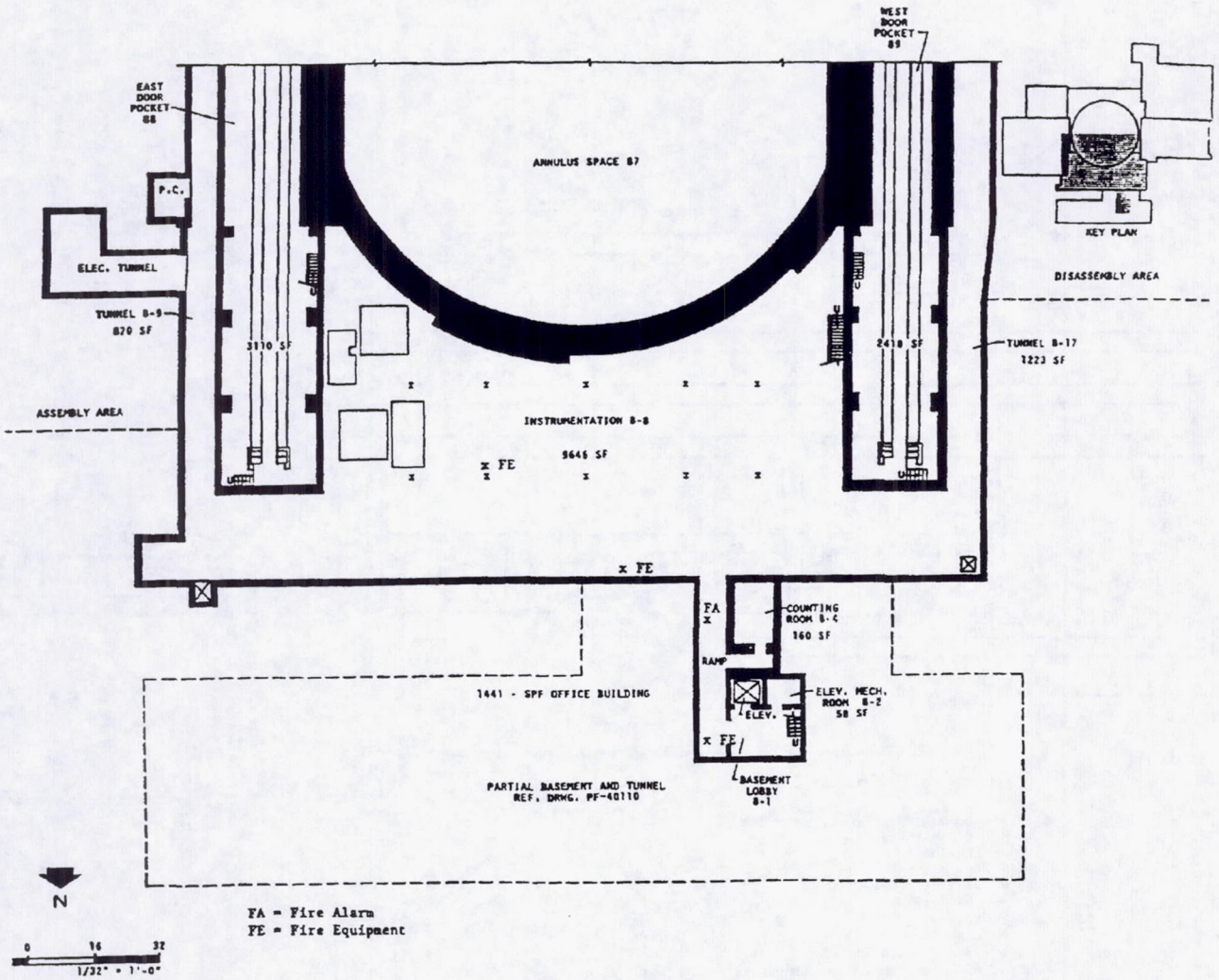

Figure 6.1.4.—NASA Lewis Research Center-Plum Brook Station; Sandusky, Ohio. SPF test building; building no. 1411.

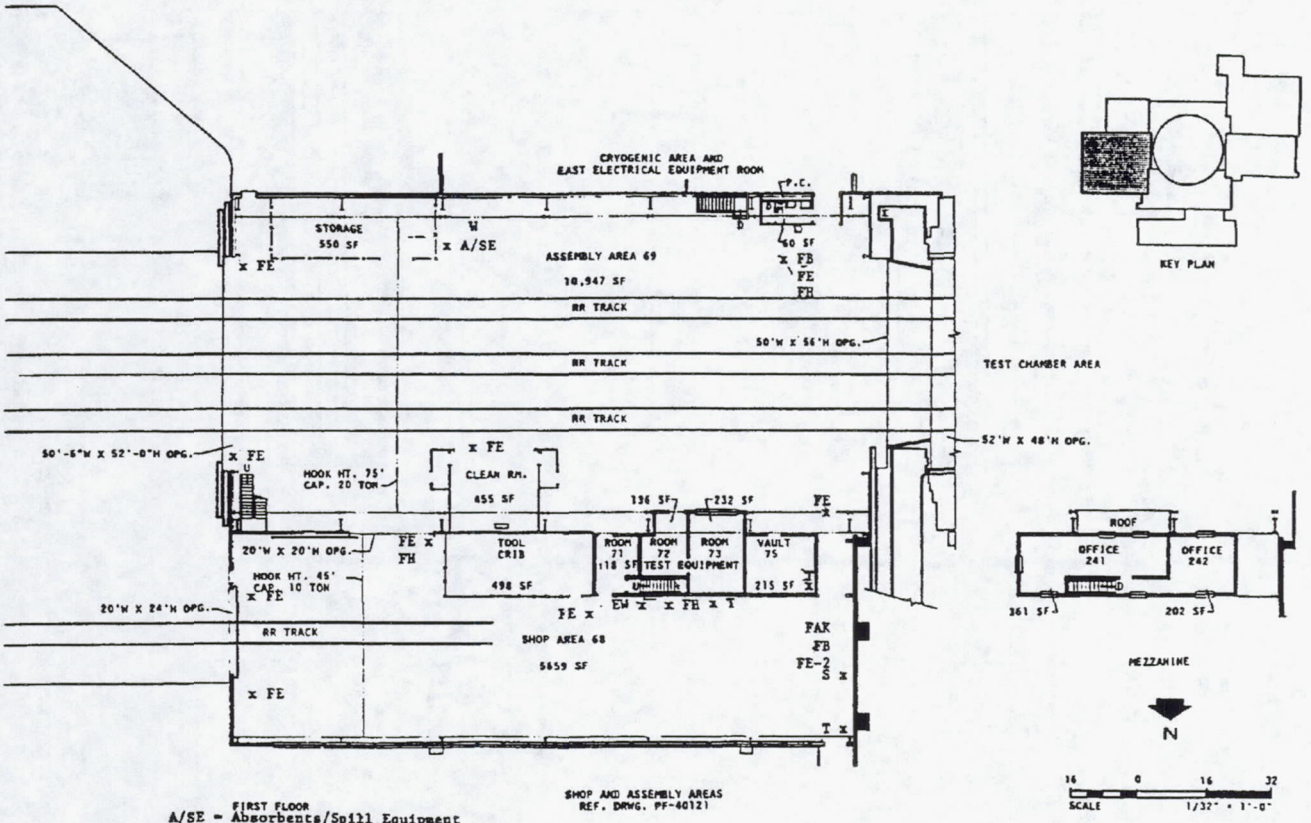

Figure 6.1.5.—NASA Lewis Research Center-Plum Brook Station; Sandusky, Ohio. SPF test building; building no. 1411.

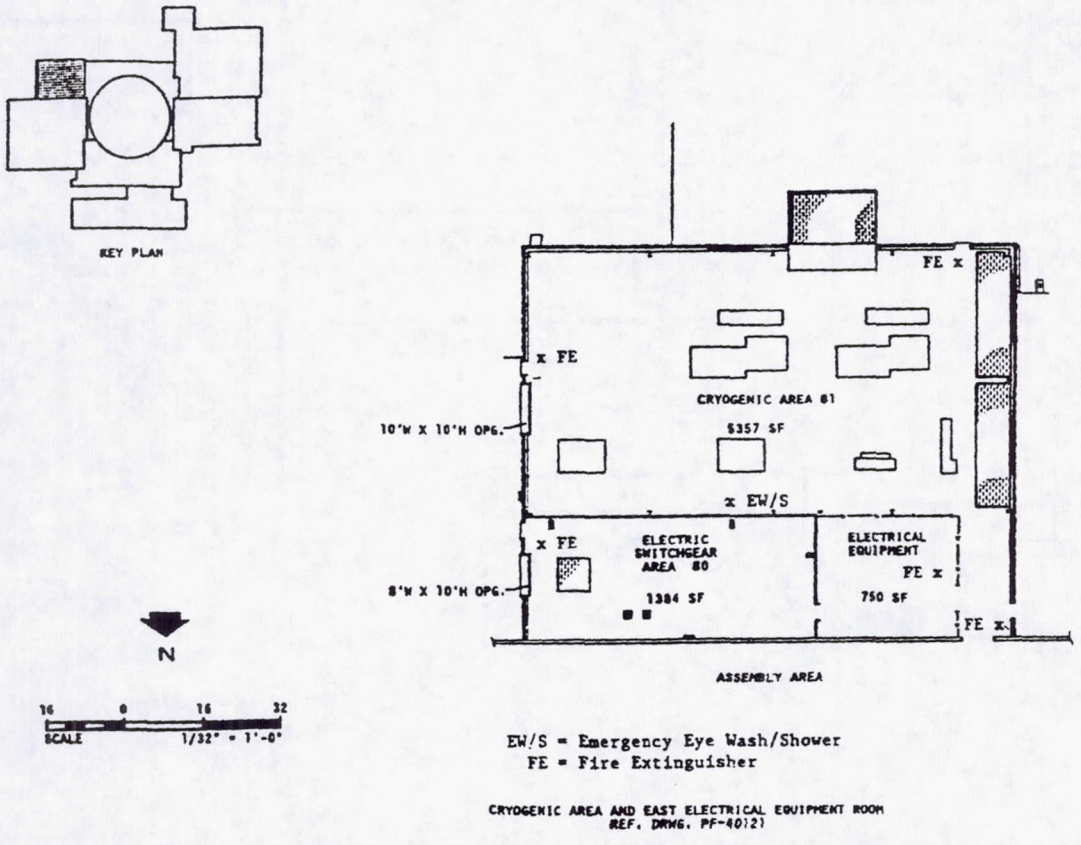

Figure 6.1.6.—NASA Lewis Research Center-Plum Brook Station; Sandusky, Ohio. SPF test building;

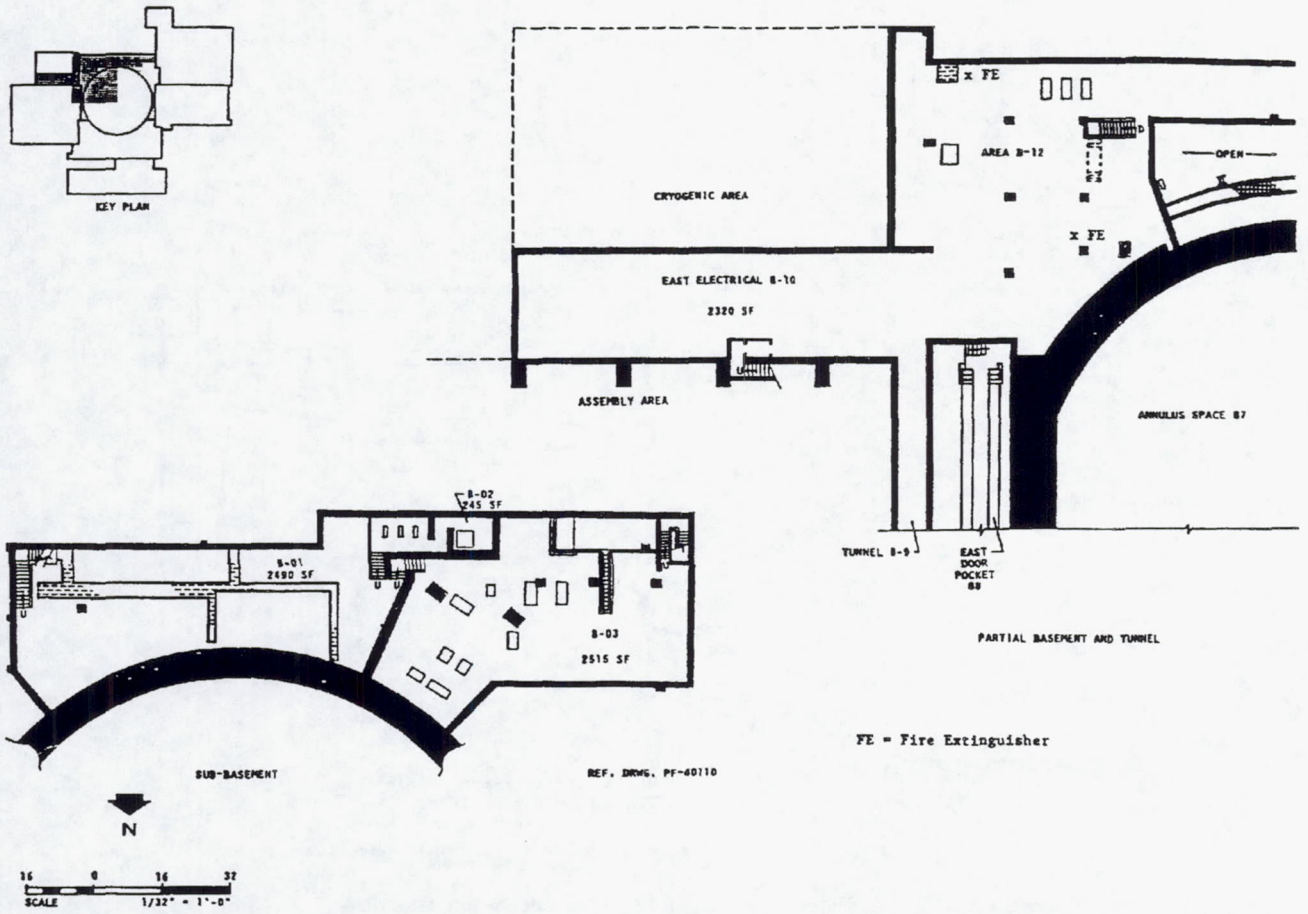

Figure 6.1.7.—NASA Lewis Research Center-Plum Brook Station; Sandusky, Ohio. SPF test building; building no. 1411.

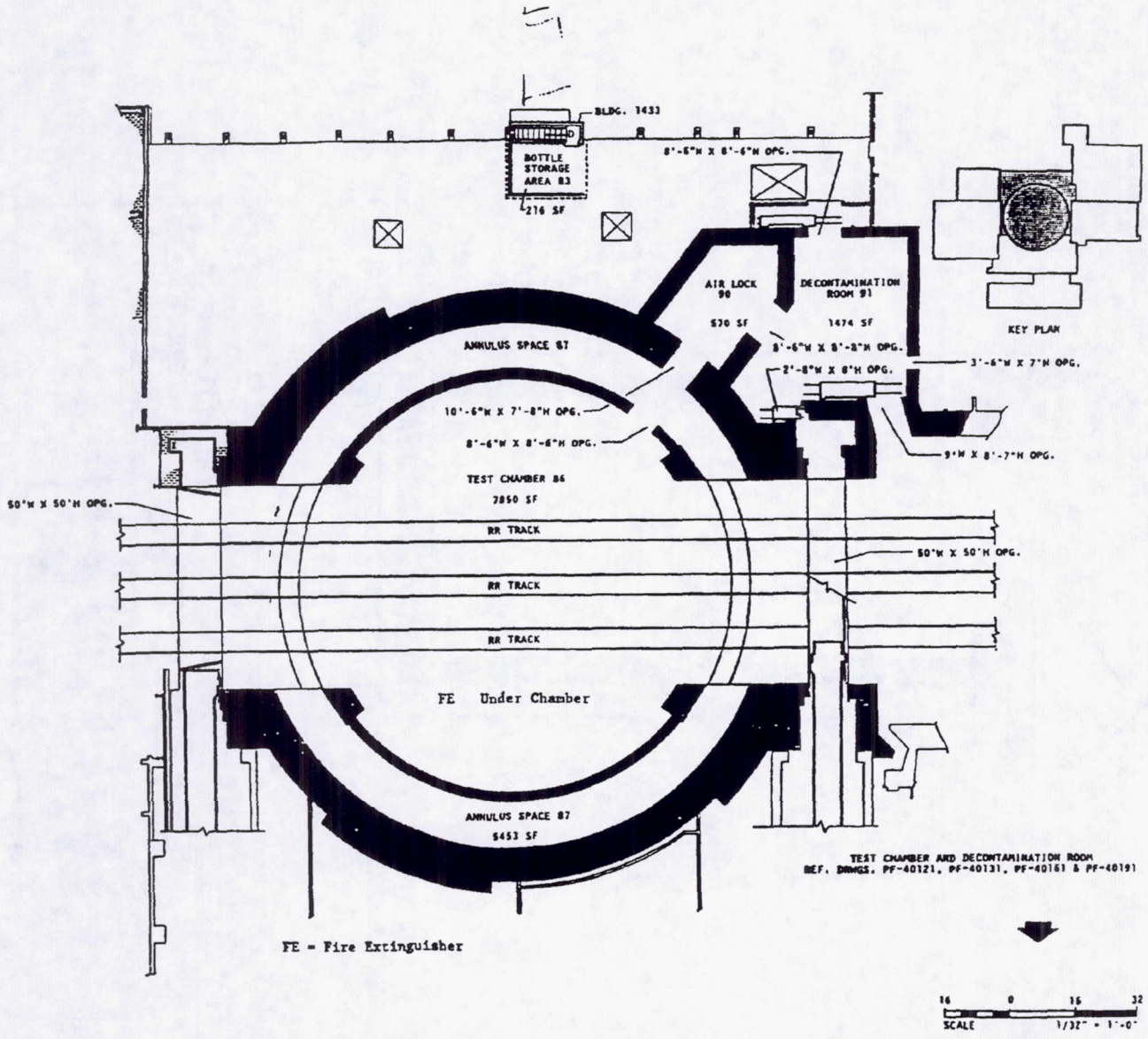

Figure 6.1.8.—NASA Lewis Research Center-Plum Brook Station; Sandusky, Ohio. SPF test building; building no. 1411.

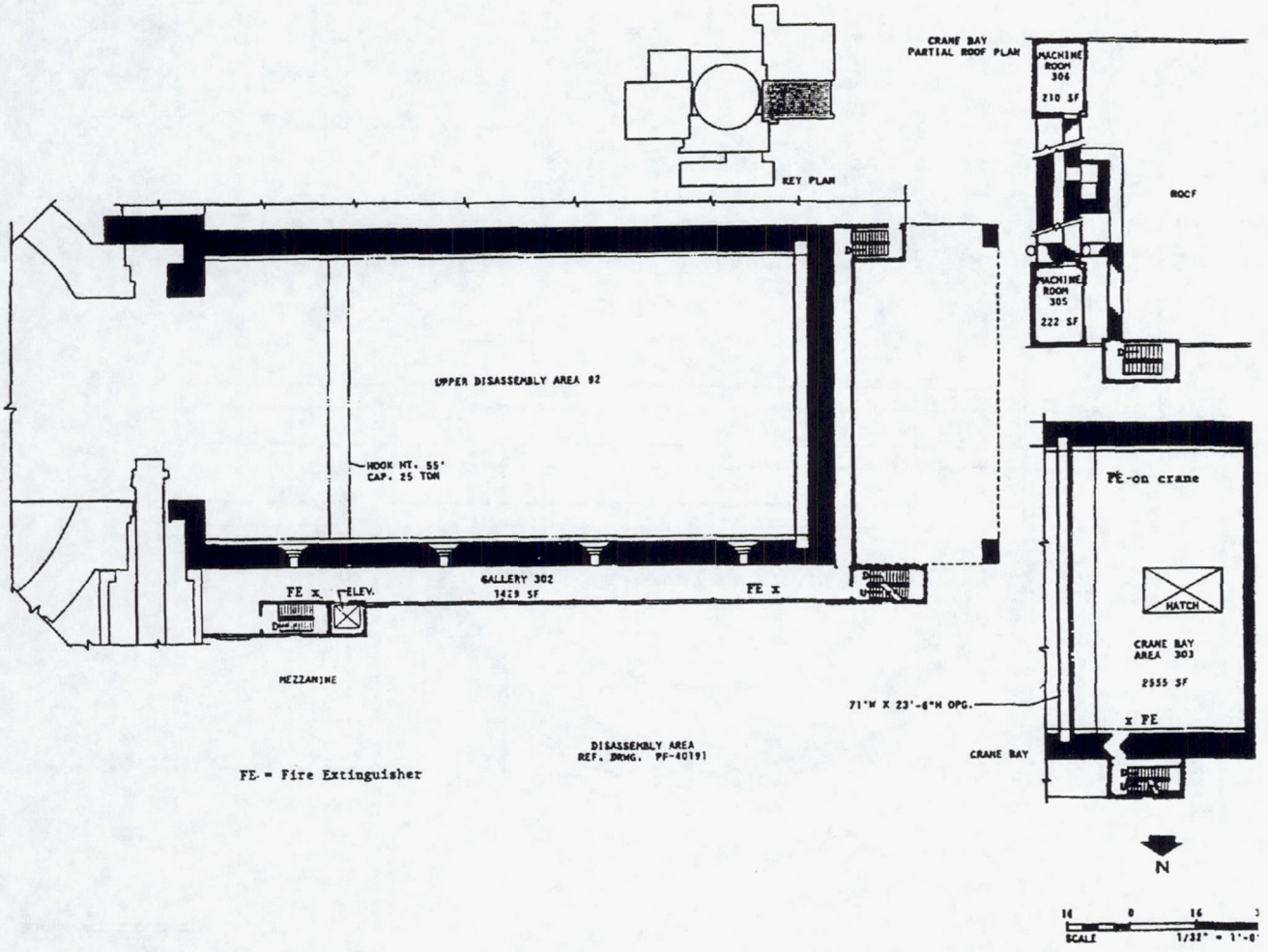

Figure 6.1.9.—NASA Lewis Research Center-Plum Brook Station; Sandusky, Ohio. SPF test building; building no. 1411.

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13. ABSTRACT (*Maximum 200 words*)

This document provides information which shows that the NASA Lewis Research Center's Space Power Facility (SPF) will be ready to execute the Space Station electric power system thermal vacuum chamber testing. The SPF is located at LeRC West (formerly the Plum Brook Station), Sandusky, Ohio. The SPF is the largest space environmental chamber in the world, having an inside horizontal diameter of 100' and an inside height at the top of the hemisphere of 122'. The vacuum system can achieve a pressure lower than 1×10^{-5} Torr. The cryoshroud, cooled by gaseous nitrogen, can reach a temperature of -250°F, and is 80' long x 40' wide x 22' high. There is access to the chamber through two 50' x 50' doors. Each door opens into an assembly area about 150' long x 70' wide x 80' high. Other available facilities are offices, shop area, data acquisition system with 930 pairs of hard lines, 7 megawatts of power to chamber, 245K gal. liquid nitrogen storage, cooling tower, natural gas, service air, and cranes up to 25 tons.

14. SUBJECT TERMS

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